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(71) Applicants
Telephone Cables Limited,
(United Kingdom),
Chequers Lane,
Dagenham,
Essex RM9 6QA
(72) Inventors
John Derek Smithies Hinchliffe,
Oliver Sanders Johnson.
(74) Agent and/or Address for Service
H.V.A. Kirby,
The General Electric Company plc.,
Central Patent Department,
(Wembley Office),
Hirst Research Centre,
Wembley,
Middlesex HA9 7PP.

(54) **Optical fibre cable**

(57) An optical fibre cable comprises a package formed as an extrudate (1) having a plurality of longitudinally-extending closed channels (5) with one or more optical fibres (6) loosely accommodated in at least one of the channels, the fibre or fibres having been introduced into the channel or channels during the extrusion process and each having a length greater than the length of the channel in which it is accommodated, thus reducing the risk of the fibre or fibres being subjected to tensile stress during manufacture or subsequent use of the cable. Preferably the package is twisted following extrusion such that the channels and the fibre or fibres follow a continuous or periodically reversed helical path.

Fig. 1.

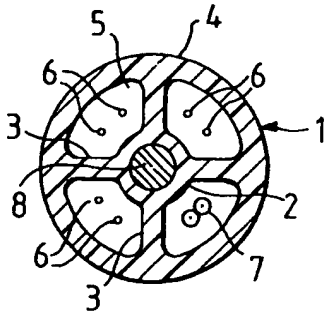

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Fig.1.

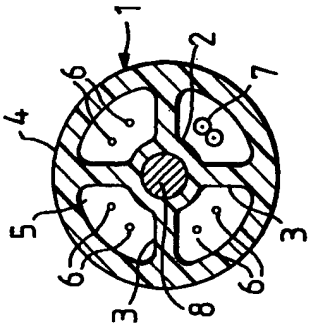


Fig.2.

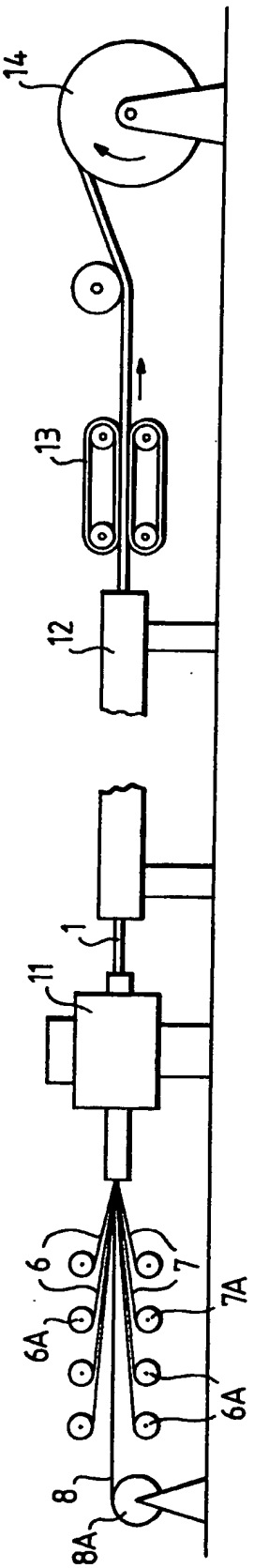


Fig.3.

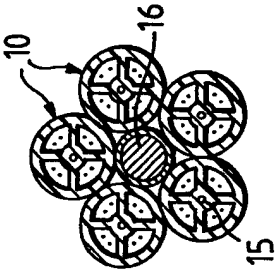


Fig.4.

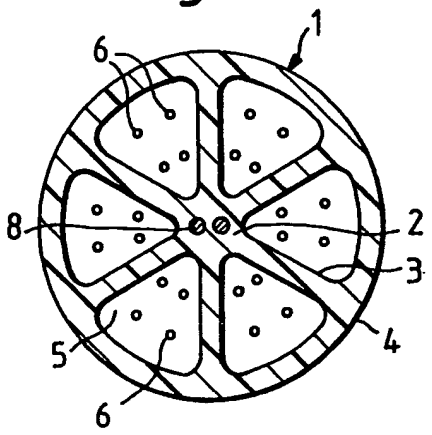


Fig.5.

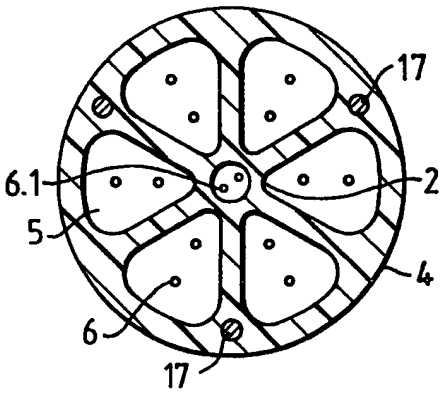


Fig.6.

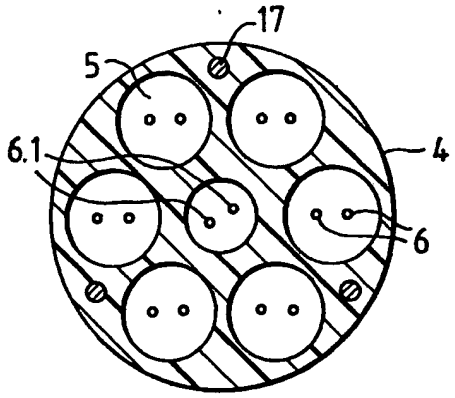
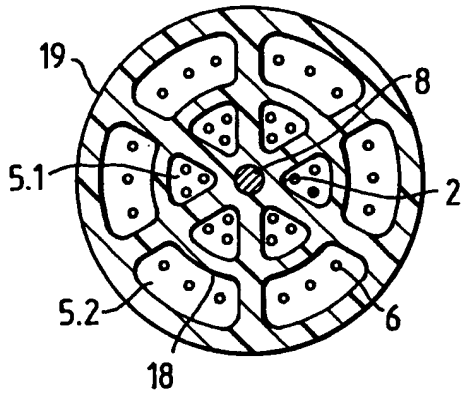


Fig.7.



SPECIFICATION

Optical fibre cabl

This invention relates to optical fibre cables, that is to say cables of the kind incorporating one or more optical fibres accommodated in a protective cover, which is also known as a package and will hereinafter be referred to as such, and relates also to a method of manufacturing such cables.

According to the invention in an optical fibre cable the protective package comprises an extrudate formed with a plurality of longitudinally extending closed channels, and one or more optical fibres are loosely accommodated in at least one of the channels, the fibre or fibres having been introduced into the channel or channels during the extrusion process and each having a natural length which is greater than the corresponding length of the channel in which it is accommodated.

By the natural length of a fibre is meant the length of the fibre if laid along a straight line.

The incorporation of the fibre or fibres within the channels during the extrusion of the package in the manufacture of the cable is simplified, and by the use of a fibre or fibres having a natural length which is greater than that of the respective channel or channels the risk of the fibre or fibres being subjected to tensile stress and therefore becoming damaged during manufacture or subsequent use of the cable is significantly reduced.

The fibre or fibres may, for example, be introduced into the extrudate at a rate greater than the rate at which the extrudate is formed.

The extrudate, which is preferably, but not necessarily, of circular form, may incorporate one or more strength or strain bearing members, hereinafter referred to simply as strength members, extending along it to assist in preventing the optical fibre or fibres being subjected to an excessive tensile force during manufacture or subsequent use of the cable. The strength member or members may be of a metal such as steel, conveniently of helically wound stranded form, or alternatively of a plastics material such as Kevlar or any other material having suitable tensile strength.

However by employing a suitable high strength material for the extrudate, the use of separate strength members may not be necessary, at least for some applications.

If one or more strength members having an appropriate coefficient of thermal expansion is/are employed the member or members may be arranged to be heated prior to the extrusion process, such that on subsequent cooling and contraction is reduces the overall length of the package, compared with the natural l ngth (as abov defined) f any fibre or fibres within it.

Th xtrudate may comprise a central core with a plurality of longitudinally extending fins radiating from it to join the outer wall of the extrudate, the channels being formed between adjacent fins. The fins may have any suitabl shape of cross-secti n and any conveni nt number of fins and channels may b provided depending up n the diameter of th cabl and the number f optical fibres required to be accommodated.

Where the extrudate has a central core the strength member or members, where provided, may be embedded within the core, the member or members then conveniently acting as a carrier on to which the package is extruded during manufacture. However the core may alternatively be hollow and provide an additional channel for accommodating one or more optical fibres. One or more strength members may then be incorporated if required in another part or other parts of the extrudate, for example in the outer wall or one or more of the fins.

The extrudate can, however, take alternative extrudable forms with the closed longitudinally-extending channels shaped and disposed in any other convenient manner. Sharp angles within the channels into which a fibre could become wedged are preferably avoided.

The extrudate is conveniently formed of a readily extrudable insulating material such as polyethylene, polypropylene or pvc, but any other suitable insulating material capable of being extruded could alternatively be employed.

It is sometimes desirable to incorporate one or more electrical conductors in an optical fibre cable, for example to provide electrical power to repeaters or to provide a monitoring facility. Accordingly one or more electrical conductors may be accommodated in at least one of the cable channels. If two or more such conductors are disposed within the same channel they should, of course, be mutually insulated, for example by being individually provided with insulating coatings or sheaths. However in some cases strength members themselves could be formed of, or incorporate, a metal of suitably high electrically conductive properties and be utilised for this purpose. In the case of a steel wire employed as a strength member the wire may, for example, be copper clad to enhance the conductivity of the member.

A cable may comprise a plurality of packages as above described each accommodating one or more optical fibres, and formed into a composite cable, for example by being wound in helical fashion. In some cases the units may be wound around a common central strength member and in such a case the individual packaging units need not themselves incorporate a strength member within the central core, although it may, in some instances, be desirable to provide a central carrier for the packaging unit to extrude on to. Such a carrier, as it is not required to provide any substantial degree of tensile strength, may be in the form of one or more glass fibres, not necessarily of the optical type, or a thin metal wire, although other materials could alternativ ly be mployed for this purpose.

According to an th r aspect of the invention in a method f forming an optical fibre cable a package f xtrudable insulating material is f rmed, by extrusion, with a plurality of l ngitudinally-extending channels, and one or more optical fibres are introduced into at least one of the channels during the xtrusion process, the rate of introduction of th fibr or fibr s being such that each fibre has a

natural length greater than the corresponding length of the channel in which it is accommodated.

During manufacture the package may be twisted following the extrusion process such that any channels spaced from the package axis, and hence the optical fibre or fibres accommodated therein, are disposed in a helical fashion about said axis, for example as described in co-pending Patent Application No. 8236506. The direction of twist may be periodically reversed at short intervals, preferably not more than half a turn, so that the or each fibre has a substantially sinusoidal configuration projected on to a cylindrical surface coaxial with the package. The package may in some cases be given a degree of overtwist and subsequently allowed to relax slightly before the extrudate has set.

Several different optical cables in accordance with the invention will now be described by way of example with reference to Figures 1 to 7 of the accompanying schematic drawings, in which

Figure 1 represents a transverse cross-section of one form of cable in accordance with the invention,

Figure 2 represents, diagrammatically, apparatus for manufacturing such a cable, and

Figures 3 to *7* represents transverse cross-sections of a number of different cables.

Referring first to Figure 1 the cable comprises a package 1 formed as an extrusion of, for example polyethylene or pvc, and comprising a central core 2 having a plurality, in this case four, longitudinally extending, uniformly spaced fins 3 radiating therefrom and joined at their outer ends to a circular-sectioned outer wall 4.

Each of the channels 5 formed between adjacent fins 3, with the exception of one, contains two optical fibres 6, and the remaining channel contains a pair of electrical conductors 7, for example of copper, mutually insulated from each other.

Both the optical fibres 6 and the conductors 7 are loosely accommodated within the respective channels 5, and the core 2 contains, embedded therein, a strength member 8 of helically wound steel strands.

The fibres 6, the conductors 7 and the strength member 8 are introduced into the cable during the extrusion process, which will now be described with reference to Figure 2.

The optical fibres 6, the conductors 7 and the strength member 8 carried by respective drums 6A, 7A, 8A are led through guides (not shown) into an extruder head 11 from which a polyethylene package 1 of the shape shown in Figure 1 is extruded on to the strength member 8, the fibres 6 and the conductors 7 being guided into the respective channels that are formed.

From the extruder head 11 the cable is drawn by a belt capstan 13 into a water trough 12 to harden the polyethylene and is finally wound on to a take-up drum 14.

Means (not shown) are employed to ensure that the fibres are slightly longer than the surrounding package, so as to avoid them being subjected to any excessive tensile stress.

The cable may be twisted periodically in opposite directions in the manner described in co-pending Patent Application No. 8236506, to give the channels 5, and hence the optical fibres 6 accommodated therein a reversing helical configuration. In order to facilitate movement of the fibres within the package a solid lubricant such as powdered talc is conveniently applied to the fibre surfaces prior to the extrusion process.

Figure 3 shows an alternative form of cable comprising a number, for example six as shown, of cable units 10 each similar in construction to that illustrated in Figure 1 but of smaller diameter, and having in place of the central strength member 8, a single wire or fibre 15 which provides a carrier on to which the respective package is extruded, optical fibres being similarly introduced into the channels 5 formed between adjacent fins 6 during the extrusion process.

The individual cable units are formed substantially as described with reference to Figure 2, and are then wound helically around a common insulated strength member 16 utilising a known cable winding technique. The central strength member can again be formed from helically wound steel strands, conveniently coated with polyethylene.

The whole assembly may be surrounded by an outer protective sheath.

In some cases the individual carriers 15 may be dispensed with.

In a modification each of the individual packages may incorporate a strength member as in the case of the cable described with reference to Figure 1; the individual units may be wound round a common central strength member, as in the Figure 3 embodiment, or may simply be wound together in helical fashion with the common central strength member being omitted.

Typically the diameter of the cable illustrated in Figure 1 would be of the order of 10mm, although each of the units forming the cable illustrated in Figure 3 could have a diameter of only 3mm. However the size will, of course depend on the construction and the number of optical fibres which need to be accommodated.

Whilst the cable units of Figures 1 and 3 have been shown with four fins any other convenient number, for example five or six, may be employed, and instead of polyethylene other extrudable plastics material could be used to form the package.

One such cable having six fins 3 radiating from a central core 2 is illustrated in Figure 4, this cable being formed in a similar manner to that of Figure 1. In addition the core 2 of this cable has embedded within it a plurality of strength members 8, for example two as shown, of helically wound copper clad steel strands which provide conductors for the transference of electrical power.

A single strength member may take the place of the plurality of strength members in the core 2 if desired, and one or more electrical conductors may be accommodated in at least one of the cable channels 3.

In a modification of the cable illustrated in Figure 4 the core 2 is made hollow, as shown in Figure 5, and it may then accommodate one or more optical fibres as at 6. One or more strength members, which may or may not be formed of or incorporate a metal

having good electrically conductive properties, so that they can be used for the transference of electrical power, are then embedded in another part of the extrudate, for example the outer wall as shown at 17. A further modification is illustrated in Figure 6.

An alternative form of cable is illustrated in Figure 7. This again comprises an extrudate 1 of polyethylene or pvc having a central core 2, in which is embedded a strength member 8, and provided with fins 3 radiating from it as in the first embodiment. This cable, however, incorporates an inner wall 18 spaced radially from the core 2 and the outer wall 19 to provide an inner and an outer series of channels 5.1, 5.2 respectively. Some or all of the channels accommodate one or more optical fibres as at 6.

Electrical conductors may alternatively be provided in one or more of the channels, or may replace the single central strength member 8. In a further modification the core 2 is hollow and incorporates one or more loosely fitting optical fibres or conductors, one or more strength members, if needed, then being incorporated in the part or parts of the extrudate other than the core.

The invention is not restricted to cables having the forms of extrudate illustrated and other shapes of extrudate formed with longitudinally extending channels of any convenient shape of cross section into which optical fibres, and possibly electrical conductors, are introduced during the extrusion process, could alternatively be employed.

For example in a further modification in which a cable has a plurality of channels spaced around a central core with the outer wall of the package forming the walls of the channels, at least one of the channels contains an elongate member capable of being drawn radially outwards from an end of a length of cable to split the respective section of the wall and provide access to any fibre or fibres within the respective channel for jointing purposes. Alternatively at least one section of wall bounding a channel may be formed with a region extending along the cable which is of thinner cross-section than the remainder of the wall, enabling it to be more easily cut to provide access to any fibre or fibres within the channel, and in some cases it may be formed with at least one flap closing the respective channel but openable to provide access to any fibre or fibres within it.

CLAIMS

1. An optical fibre cable comprising an extrudate formed with a plurality of longitudinally extending closed channels, and one or more optical fibres loosely accommodated in at least one of the channels, the fibre or fibres having been introduced into the channel or channels during the extrusion process and each having a natural length which is greater than the corresponding length of the channel in which it is accommodated.

2. An optical fibre cable according to Claim 1 wherein the extrudate incorporates one or more strength members.

3. An optical fibre cable according to Claim 1 or 2 wherein the extrudate comprises a central core with a plurality of longitudinally extending fins radiating from it to join the outer wall of the extrudate, the channels being formed between adjacent fins.

4. An optical fibre cable according to Claim 3 having one or more strength members embedded within the core.

5. An optical fibre cable according to Claim 3 wherein the core is hollow and provides a channel accommodating one or more optical fibres or electrical conductors.

6. An optical fibre cable according to any preceding Claim wherein the extrudate consists of polyethylene, polypropylene or pvc.

7. An optical fibre cable according to any preceding Claim having one or more electrical conductors accommodated in at least one of the channels.

8. An optical fibre cable according to Claim 2 having at least one strength member formed of copper clad steel wire.

9. An optical fibre cable comprising a plurality of cables according to any preceding Claim wound helically around a central strength member.

10. An optical fibre cable according to any preceding Claim in which at least one channel bounded by the outer wall of the package contains an elongate member capable of being drawn radially outwards from an end of a length of cable so as to split the respective section of wall to provide access to any fibre or fibres within it.

11. An optical fibre according to any one of Claims 1 to 9 wherein at least one section of the outer wall of the package which bounds a channel incorporates a flap which closes the channel but is openable to provide access to any fibre or fibres within it.

12. A method of manufacturing an optical fibre cable wherein a package of extrudable insulating material is formed, by extrusion, with a plurality of longitudinally extending channels, and one or more optical fibres are introduced into at least one of the channels during the extrusion process, the rate of introduction of the fibre or fibres being such that in the finished cable each fibre has a natural length greater than the corresponding length of the channel in which it is accommodated.

13. A method of manufacturing an optical fibre cable according to Claim 12 wherein the fibre or fibres is/are introduced into the extrudate at a rate greater than the rate at which the extrudate is formed.

14. A method according to Claim 12 in which the package is twisted following the extrusion process such that any channels spaced from the package axis and the optical fibre or fibres accommodated therein are disposed in a helical fashion about the axis.

15. A method according to Claim 14 wherein the direction of twist is periodically reversed at intervals of not more than half a turn so that the or each fibre has a substantially sinusoidal configuration projected onto a cylindrical surface coaxial with the package.

16. A method according to Claim 15 wherein the package is given a degree of overtwist, and is

subsequently allowed to relax slightly before the extrudate has set.

17. A method according to any one of Claims 12 t 16 wher in a solid lubricant is applied to the fibre surfaces prior to the extrusion process.

18. A method of manufacturing an optical fibre cable carried out substantially as hereinbefore described with reference to Figure 2 or the accompanying drawings,

19. An optical fibre cable substantially as shown in and as hereinbefore described with reference to Figure 1 or any one of Figures 3 to 7 of the accompanying drawings.

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